Investigating the potential for a transition to agroforestry as a sustainable and economically viable alternative to traditional intensive farming methods in the region of Madre de Dios, Peru

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Abstract

This project aims to investigate alternative income sources for farmers in the Madre de Dios region of Peru, specifically focusing on land sharing as an alternative to traditional intensive farming methods. Highlighting the issue of deforestation and its negative environmental impacts and emphasising the significant contribution of agriculture and livestock to forest reduction. The proposed research focuses on land sharing techniques, particularly agroforestry, which combines farmable produce with native trees to promote biodiversity and reduce reliance on monocultures. The study plans to compare the environmental impact and income potential of land sharing agroforestry with traditional farming methods at the Finca las Piedras site in Madre de Dios. Through gathering data from both traditional methods of farming, as well as local attempts at agroforestry, the research will create complete life cycle assessments in order to simulate potential income and environmental impact when using farming techniques on the plot of Finca Las Piedras.

Introduction

Deforestation takes 150 thousand hectares of Perus forest every year (Luque-Ramos, 2021) and globally contributes to 15% of all carbon emissions (Rico-Straffon, et al., 2023). Industries such as gold mining, logging, and agriculture have contributed to this (Nicolau, et al., 2019) (Rico-Straffon, et al., 2023), with agriculture and livestock being regarded as the most significant source of forest reduction (Anzualdo, et al., 2022). Efforts have been made to protect rainforest, including 46 protected areas in Peru, covering 19 million hectares (Finer M, 2015). However, forest continues to be transformed into agricultural land. There is belief that as long as certain volumes of rainforest are protected, others can be cleared for intensive farming purposes.

Supporters of land sparing believe that having protected land in some areas will combat the damage done to biodiversity by intensive farming methods including use of pesticides, fertilisers, and destruction of land (Green et al. 2005) (Egan & Mortensen, 2012).

However, this idea underestimates the significance of agricultural land in creating habitat for a number of species. 80% of priority land for mammal conservation is found in areas of agriculture, with the primary land use where the majority of populations are located being livestock or crop production (Baudron, et al., 2021). Furthermore, there has been a serious decline in plant species diversity in many agricultural lands for decades (Egan & Mortensen, 2012). Meaning that intensification of agriculture and changing farming techniques can cause significant damage to biodiversity (Baudron, et al., 2021). This demonstrates

the importance of recognising agricultural land as important ecosystems in its own right. Furthermore, diversity within agricultural land contributes to soil quality and stability, health of pollinators (Egan & Mortensen, 2012), reducing the need for chemical interference to promote growth and reduce pests. Meaning increasing biodiversity in agricultural land could not only benefit the environment, but also improve crop yield and income for farmers.

Achieving this requires alternative farming methods in order to provide income for farmers while preserving their land for a variety of ecosystem services beyond crop production. This could potentially be provided by land sharing techniques, where agroforestry provides farmable produce without having monocultures that prevent biodiversity. Multiple types of land sharing have been explored, with varying levels of success. Phrases such as ecological intensification describe the switch from human led farming to increasing yield through natural ecosystem services (Phalan, 2018). This translates into farming methods with varying land use across plots. Agroforestry involves farming plots combined with native trees, which provides ecological benefits in addition to producing healthy crops. This method of farming requires less man-made intervention, as well as potentially creating healthier land and increased biodiversity.

Agroforestry has been explored in Peru in an attempt to stop deforestation by small scale farmers (Parodi, et al., 2022), who often clear forest to plant monoculture crops. It could provide a successful alternative, however, there are still questions on how to manage species to maximise both economic and environmental benefits (Joe, 2011). By exploring the current farming practices in Madre de Dios, the feasibility of switching to agroforestry can be determined. This is an ideal environment for study, as the region has seen successful promotion of sustainable farming, with over 80% decrease in farming of rice and corn between 2010 and 2017, encouraged by the promotion of cacao and copazu farming (Andreotti, et al., 2021). If land sharing creates healthier land, has a lower environmental impact, and also provides sufficient income to farmers, it could be a viable alternative, resulting in lower levels of deforestation and maintaining healthier ecosystems in the Madre de dios region.

Methods

Field Observations

To gain insights into traditional farming methods, on-site field observations were conducted within the vicinity of Finca las Piedras. The objective was to understand the operational systems of these farms.

Participant Recruitment

The Director of the Alliance for a Sustainable Amazon, Johana Reyes, provided valuable assistance by compiling a list of local farmers available for contact. Subsequently, these farmers were approached through in-person visits to their farms. They were then asked about their willingness to participate and answer questions related to their farming practices. Translators were present during these interactions to facilitate interviews conducted in Spanish.

Farmers Market Interviews

To enhance the breadth of the study, interviews were also conducted at the farmers market in Puerto Maldonado. The market visits were scheduled on consecutive weekends, Saturday, and Sunday, to encompass a wider pool of farmers from various locations within

Madre de Dios. This strategy aimed to capture a more comprehensive range of data.

Informed Consent and Briefing

Prior to commencing interviews, participating farmers were given a clear explanation of the ASA organisation, how their provided information would be utilised and the overarching purpose of the research project.

Upon agreeing to participate, the farmers were guided through a series of questions categorised as follows:

1.Farm Profile and Experience
2.Planting and Harvesting Techniques
3.Irrigation, Fertilisation, and Pest Control Strategies
4.Crop Selling Process
5.Challenges including Pest Management and Weather
6.Government and Non-Governmental Support

Additional farmers were identified by consulting local residents on which of their neighbours were involved with agriculture practices. This approach broadened the spectrum of interviewees.

Market Observations

While at the farmers market, aside from interviews, keen observations were made regarding crop variations and interactions between farmers and buyers.

Data Collection and Analysis

After successfully collecting information from twelve individual farmers, the data was organised and processed using Excel software. This allowed for comprehensive analysis of trends pertaining to individual farms, specific crops, and distinct farming techniques.

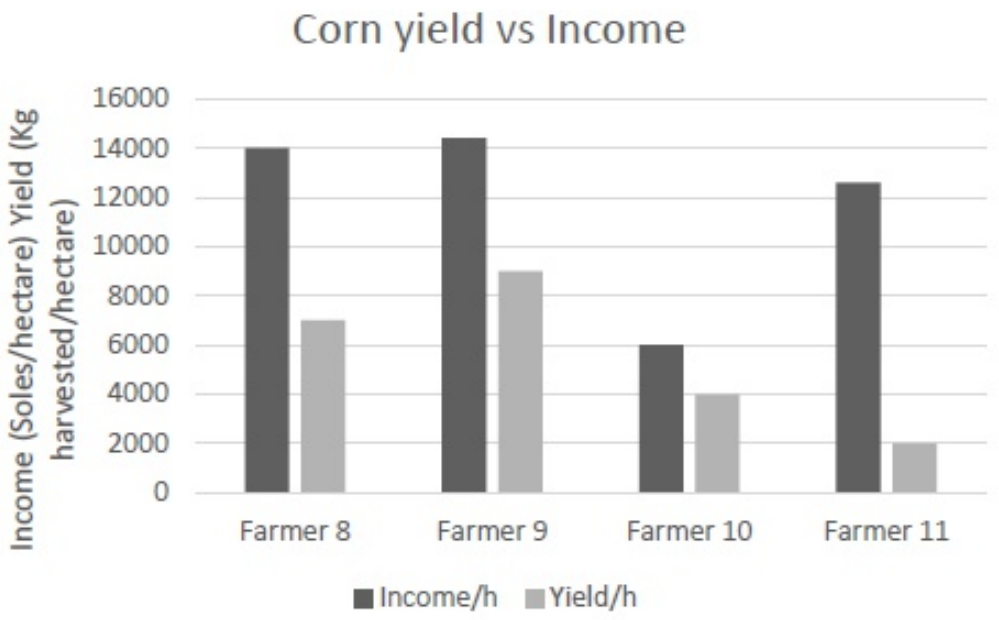
Economic Viability and Agroforestry Assessment

The assessment of economic viability for both prevailing farming methods and the potential for agroforestry was executed through the analysis of costs, revenues, and overall financial performance. This encompassed an understanding of factors such as crop yields, labour requirements, input costs, and market prices. This analysis facilitated an evaluation of the efficiency of current farming methods and the potential for future modifications.

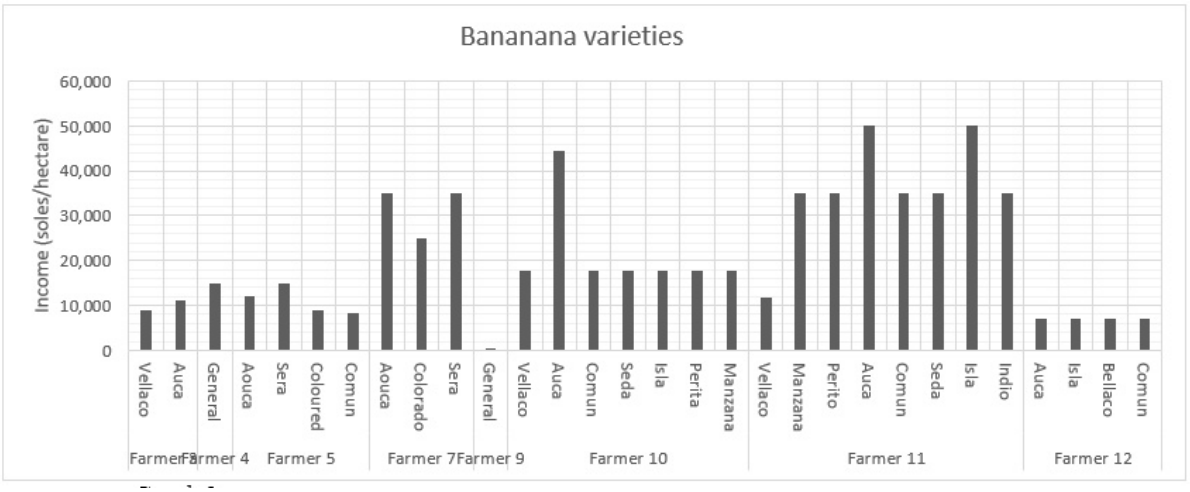
Farming Techniques and Environmental Analysis

Farming techniques were deconstructed into distinct life cycle stages encompassing raw material acquisition, crop production, transportation, processing, and distribution. This meticulous examination allowed for the determination of environmental impacts and economic influences at each stage. Additional insights were gleaned through comprehensive research on farming techniques, crop varieties, and agroforestry practices

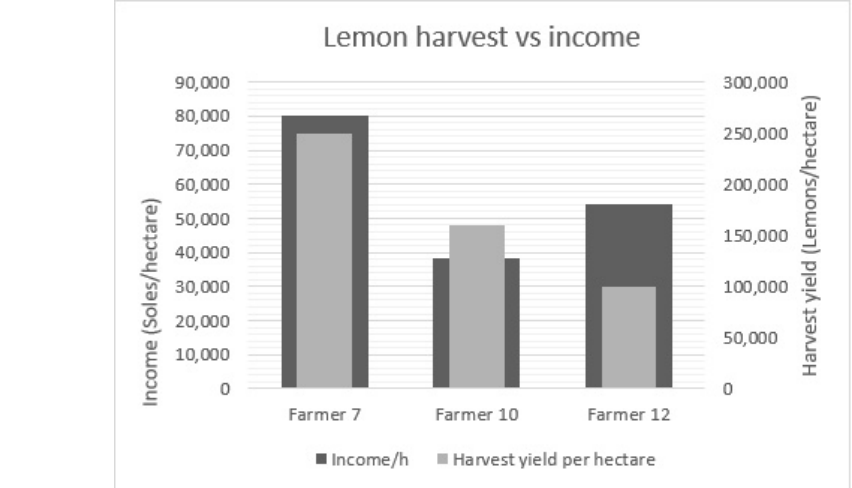
Results



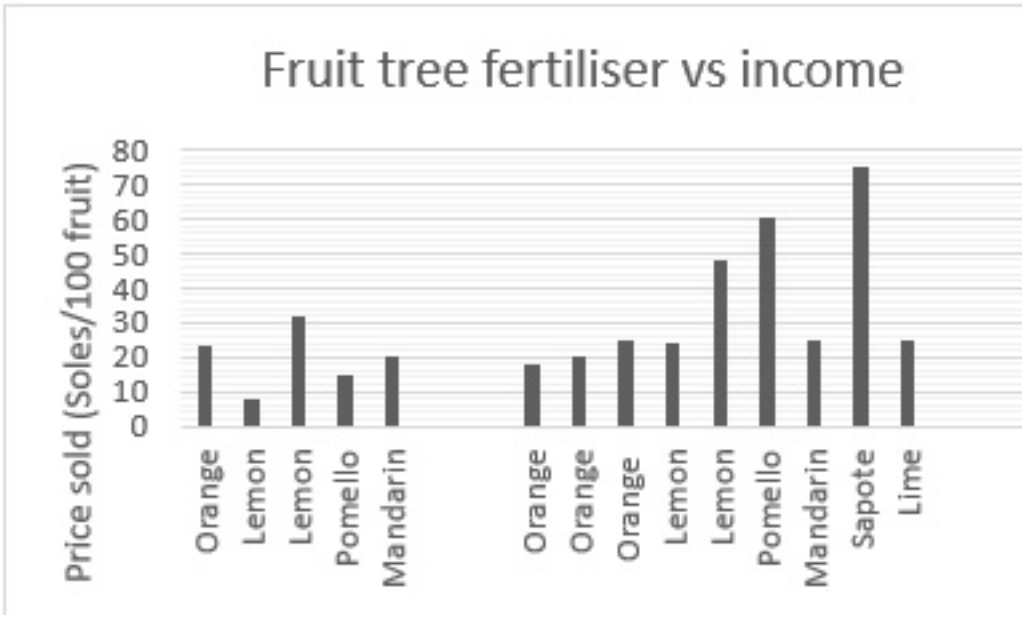
Graph 1



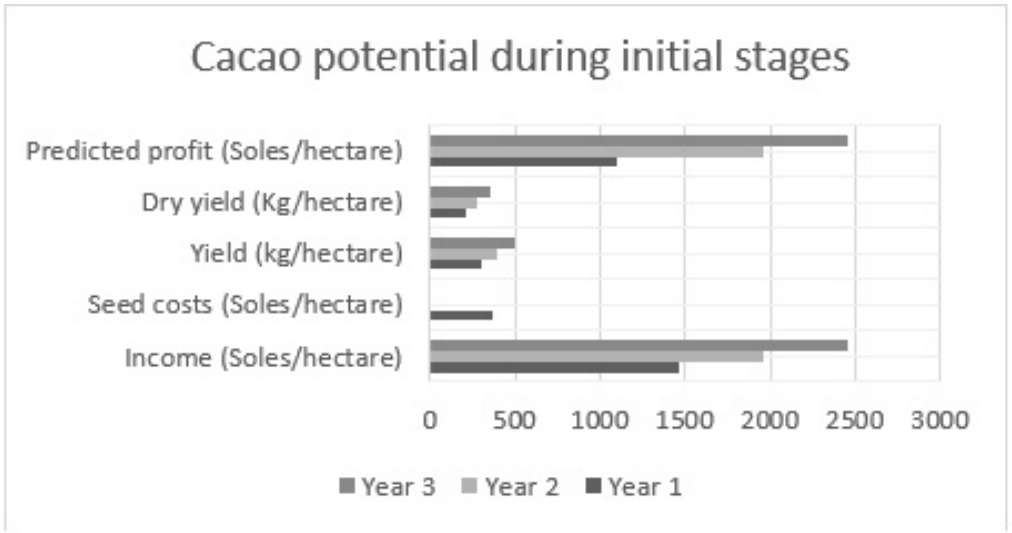
Graph 2



Graph 3



Graph 4



Graph 5

No. Hectares	Crop	Income	Pesticide cost	Fertiliser cost	yield /kg	%Farm area	%Total income
7h	Banana	49000	1085	11200	24500	35	17.87
3h	Avocado	69000	465	4800	103500	15	43.76
2h	Orange	10714	310	3200	10000	10	3.91
5h	Lemon	120000	775	8000	40000	25	43.76
3h	Cacao	25500	465	4800	3000	15	9.3
		Total income	Total pesticide/herbicide cost:				
		274,214	35100				

Table1: Farmer 12

Discussion

The expectation when beginning this study was that agriculture techniques in Madre de Dios must be inherently harmful to the environment, which would explain the extensive deforestation caused by farming. Upon conducting the twelve interviews, it was clear that farmers do have an interest in sustainability, multiple farmers reported planting native tree species, among other attempts to lessen environmental impact. The main issue appears to be inefficiency in farming methods, resulting in unnecessary waste and greater land use. There is high potential for agroforestry systems but a lack of education and government intervention. Every interview concluded that government support is unreliable, with signs of corruption that prevent any real benefit, as well as creating a sense of distrust from farmers.

Farming techniques

The agricultural landscape in Madre de Dios showcases a strong emphasis on fruit farming, accompanied by the cultivation of corn, which emerged as the predominant crops among the farmers interviewed. Farmers have an average of 5 individual crops, though the adoption of agroforestry practices appears to be limited. This could be attributed to a lack of awareness and knowledge. Except for one interviewee, who possessed formal agricultural education, the rest of the farmers interviewed learned their practices from familial traditions, community members, and personal experimentation.

When asked about their crop selections, a pattern emerged where most farmers combined crops traditionally grown within their families alongside novel crops introduced by NGOs through seed distribution initiatives. In particular, many cacao farmers began farming due to programmes to promote cacao, however few have reached a stage where this has become profitable. This demonstrates the underlying theme seen across many interviews, that farmers are open to support and adaptation, but rarely see the support needed after preliminary stages.

However, this willingness in farmers to try new techniques, even when they have mainly farmed very traditionally in the past, means if they had access to support and learning, a switch to agroforestry could be possible. Successful adoption, however, would rely on structured instruction, as existing farming techniques predominantly stem from experiential learning, which though valuable, lacks precision.

Out of the twelve surveyed farms, five abstained from utilising chemical fertilisers or pesticides altogether, while an additional two solely employed disinfectants for banana saplings and not for the cultivated fields. Graph 4 demonstrates the price of various fruits, categorised into non-fertilized, naturally fertilised, and chemically fertilised produce. There isnt a distinction between price of organic fruit compared to non-organic and using chemicals on crops generally shows little improvement to yield. This presents an opportunity for farmers to make a relatively seamless transition to organic farming practices, particularly given that many already employ organic methodologies. Interestingly, when speaking to farmers who claimed to be organic, none seemed to have knowledge of organic certifications. Education on certifications could provide increased opportunity for environmentally conscious farmers who have not had the opportunity to benefit from adopting sustainable practices. Only one farmer mentioned governmental officials checking farms for sustainable techniques, which suggests there is little awareness across the

sector.

One of the main issues facing farmers is lack of water during the dry season. Only 3 farmers interviewed had watering systems in place, additionally one farmer relied on additional workers for watering during the dry period, and another relied on manual water collection from a nearby river.

For the remaining respondents, financial constraints made irrigation systems unfeasible, despite five farmers reporting depleted harvest yield or quality due to lack of water. Although aligning planting schedules with the wet season reduces water consumption, lack of proper irrigation risks reduced crop health, resulting in high levels of waste. This wastage in turn necessitates larger land usage to secure acceptable yields, ultimately driving deforestation. More efficient farming methods have the potential to mitigate this environmental impact, requiring less land while improving farmers' income. Agroforestry, in particular, holds potential for enhancing soil moisture retention through tree roots and providing crucial shade. This has been seen in other countries such as Kenya, where agroforestry farmers experience protection from both flooding and drought (Quandt, 2020), which are two of the major issues facing farmers in Madre de Dios. One farmer claimed to have entire harvests of corn wiped out by high winds, an issue which could be greatly reduced through the use of wind breaks created by trees. Windbreaks in agroforestry systems prevent erosion and create habitat for animals, in addition to improving water retention for nearby crops (Wilson & Lovell, 2016). Furthermore, native tree species have adapted to thrive in Perus climate, so are more likely to withstand extremes of the wet and dry season (Shelef, et al., 2017).

A further issue experienced by the majority of farmers interviewed was pest management, a consistent approach to dealing with this was not identified. Solutions included fencing off crops to keep out agoutis, shooting at birds, killing and eating agoutis, and leaving additional food out to distract animals from crops. Many of these solutions were harmful to animal species as well as being relatively ineffective. Multiple organic farmers also reported struggling with insects and disease, as they dont seem to have an organic alternative to pesticides. If pesticides are necessary for certain crop species, agroforestry can at least reduce negative environmental impact, since having a variety of trees can provide host for microbial populations which can break down pesticides (Wilson & Lovell, 2016). For organic farms, having mixed trees and increased biodiversity in land shared areas encourages healthy populations of natural enemies of pests, therefore keeping their populations naturally low (Dix, et al., 1999).

Enterprise opportunities

When interviewing farmers, as well as making observations at markets, there are a number of ways farmers may wish to adapt their selling process if they were to switch to agroforestry, in order to make it an economically viable option.

Graph 3 illustrates that there's no clear connection between higher lemon yields and increased income. This aligns with the broader observation that many farmers face financial losses due to pricing challenges. For instance, Farmer 10 sells lemons for just three soles per kg, while Farmer 12 sells them for seven soles per kg at the same market. Since most farmers lack

precise knowledge of their expenses, pricing tends to be influenced more by supply and demand rather than specific profit margins, especially when selling in markets. Table 1 depicts the profit margins for one farmer, showing lemons provide a disproportionate level of income in comparison to other crops farmed in the same area of land. This is due to a current shortage of lemons, showing the impact supply and demand has on farmers income, meaning unexpected gains and losses are very common.

Graph 2 displays the variety of bananas sold by farmers, with some types selling for as much as forty-five soles per bunch. This underscores the significance of offering a variety of produce, especially in competitive market settings where demand can fluctuate. However, this competition often leads to many farmers selling identical products, and some farmers mentioned being willing to lower prices if initial sales were not sufficient. Many farmers discussed having gifted fruits to family and friends as they are unable to sell all produce, meaning they are growing more than there is demand for, this is an inefficient business model, and wastes precious land which could be used for more lucrative production. Instead of continuing to grow large quantities of the same fruit, it could be beneficial to farmers to grow a range of crops that can be processed to gain advantage on competitors' produce. This can be seen in farmers who process their crops into value-added products.

Additional products can be produced with waste produce or as the primary purpose of cultivation, providing additional income. One farmer demonstrated a range of health drinks derived from banana tree stems. This requires no extra cost, as it is a by-product of banana farming, and can be sold for 50 soles per 3-litre bottle. Furthermore, Graph 1 shows farmer 11 makes almost the same income as farms with triple their corn yield per hectare. This is because they produce corn flour, which costs only 1 sole per kg to make but can be sold for 10 soles per kg compared to dried corn, usually sold for 1.5-2 soles per kg. Investing in a mill also enables them to create flour from surplus crops like yuca, rice, and banana. This type of production requires less land while yielding equivalent income, making it well-suited for an agroforestry system where plants can be distributed throughout the landscape and utilised for various purposes.

Additionally, selling products desired by companies rather than to general buyers at the markets guarantees a steady income by selling fixed quantities of produce at predetermined prices. For example, one cacao farmer received free cacao seeds from a nursery and established a monthly arrangement with a chocolate business, ensuring a consistent income of 81,000 soles by delivering 900 kg during harvest months.

Other farmers participating in similar partnerships described the process of verification, requiring all farms to use organic, sustainable practices in order to partake. This not only provides income opportunities for farmers but educates them on correct practices to produce high quality crops. This was initiated by AIDER, who provided cacao seeds and instruction to the farmer. AIDER signed an agreement with the United Kingdom (UK), through the Green Recovery Challenge Fund (PACT), funding support to indigenous farmers by private investors and banks, as stated in the Agroforestry business models 2022 report. Initiatives such as this are important

during a transition period when local people still have little knowledge on agroforestry. This is a positive way that Madre de Dios as a region has already been successful in promoting sustainable agriculture, however some current attempts do not show sufficient success for farmers to have cacao as one of their main income crops. Graph 5 displays the income for one farmer within the first few years of harvesting cacao. Although generating profit, even by the third year, harvest yield is not high. This emphasises the importance of external support and education in order to create planned systems to ensure farmers have sufficient income in early years of agroforestry. It seems currently not all initiatives are providing sufficient support beyond initial stages. Furthermore, one farmer described a similar partnership, along with the support received for being on indigenous land, but then proceeded to describe harmful practices such as shooting parrots who tried to eat crops. This demonstrates the difficulty in promoting new techniques, as farmers may be used to other methods which do not align with the goals of sustainable practice.

The challenge of inadequate support is underscored by a general sense of neglect expressed by all the interviewed farmers. Notably, none reported receiving assistance from the government, and many recounted instances where promises were made but support did not follow. One farmer recounted the Ministry of Agriculture's pledge to allocate funds to aid farmers, only for those funds to never materialise, with the farmer accusing certain workers of pocketing the money. This feeling of distrust could potentially impede the future adoption of sustainability initiatives, as farmers may not feel valued or believe that their needs will be addressed.

When questioning if there are any government policies or laws that must be followed, widely varied answers were received. The majority of farmers indicated the absence of specific policies governing agricultural practices, while a few mentioned periodic sanitation checks. This suggests that regulatory checks occur sporadically, and access to relevant information and guidelines is limited. This contradicts statements on how Madre de Dios is heavily promoting agriculture as a sustainable land use in alternative to mining, as farming appears to be for the most part unmonitored. Although there have been positive steps in encouraging sustainable land use through cacao farming (Andreotti, et al., 2021), the lack of policy implementation relies on farmers putting sustainable practices into place, rather than enforcing restrictions that require all farmers to use environmentally friendly farming techniques.

Conclusion

This study delved into the potential for transitioning to agroforestry as a sustainable and economically viable alternative to conventional intensive farming practices in Madre de Dios, Peru. As initial expectations suggested, the environmental impact of traditional farming methods was indeed a significant concern, contributing to extensive deforestation in the region. However, through in-depth interviews and observations, it became evident that local farmers held a curiosity, if not genuine interest in adopting more sustainable practices, including the cultivation of native tree species.

While sustainability was an interest to farmers, the key challenge emerged as inefficiency within their farming techniques and lack of economic strategy which prevented sustainable practice. This inefficiency led to wastage and larger land

requirements, exacerbating environmental stress. The study highlighted the untapped potential of agroforestry systems in mitigating these impacts, providing crucial shade, improving soil moisture retention, and reducing reliance on deforestation-driven expansion. Barriers to adopting sustainable practices included limited education and a lack of governmental intervention. The findings illuminated a lack of formal training among most farmers, with knowledge primarily passed down through familial traditions, communal networks, and personal experimentation. This lack of structured education underscores the need for targeted programs to implement effective agroforestry techniques.

Market dynamics presented further challenges. Pricing fluctuations and oversupply often led to financial losses among farmers, underscoring the need for diversified produce and value-added processing. Such approaches were found to be economically advantageous, fostering income stability and reducing wastage. Additionally diversified produce fit into plans for agroforestry, which lends itself well to crops such as cacao which are important produce for sustainable projects in Peru.

A notable theme across the interviews was the perceived lack of reliable government support. Many farmers reported promises of assistance that were unfulfilled, leading to a sense of distrust and scepticism towards governmental initiatives. Additionally, regulation gaps were evident, with limited policies governing agricultural practices and sporadic enforcement of guidelines. This indicated a need for robust policy implementation to guide farmers towards sustainable practices. Despite the challenges, some positive initiatives stood out. Collaborative partnerships with businesses, NGOs, and private investors showcased successful models of sustainable agriculture. These initiatives provided not only economic opportunities but also valuable education on sustainable practices.

In conclusion, this study unveiled the potential for a shift to agroforestry as a transformative approach to agriculture in Madre de Dios. Highlighted was the willingness of local farmers to embrace change if provided with proper education, support, and incentives. For agroforestry to thrive, structured instruction, transparent government support, and effective policies are crucial. By fostering a transition towards sustainable practices, the region can work towards striking a balance between agricultural productivity and ecological preservation, thereby contributing to a more sustainable future.

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